Influence of Bittermelon, *Momordica charantia* L. (Cucurbitaceae), on Distribution of Melon Fly, *Dacus cucurbitae* Coquillet (Diptera: Tephritidae) on the Island of Molokai, Hawaii[1]

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ABSTRACT

A study of trap catches and fruit samples showed a strong relationship between the distribution and abundance of the melon fly, *Dacus cucurbitae* Coquillet, and the abundance of cultivated hosts and feral bittermelon (*Momordica charantia* L.) in west Molokai. In general, the melon fly was distributed in all inhabited areas on the island of Molokai. In uncultivated pineapple fields near Maunaloa and Hoolehua, growth and fruiting of *M. charantia* produced large populations of *D. cucurbitae*. Mean rate of infestation was 21.8 melon flies/kg of *Momordica* and 22.1 flies/kg of cultivated cucurbits (pumpkin and watermelon). Over 8000 fruits were collected which produced 2432 *D. cucurbitae* pupae but no parasitoids. The high winds on west Molokai appeared to be unfavorable for *Opius fletcheri* Fullaway, the principal parasitoid associated with melon fly in Hawaii, but were favorable for *D. cucurbitae*.

Melon fly, *Dacus cucurbitae* Coquillet, has occurred in Hawaii since about 1895 (Clark 1898). This insect is a serious economic pest of watermelons, *Citrullus vulgaris* Schrad.; cantaloupes, *Cucumis melo* L.; pumpkins, *Cucurbita pepo* L.; squashes, *Cucurbita maxima* Duch.; cucumbers, *Cucumis sativa* L.; tomatoes, *Lycopersicon esculentum* Mill.; bell pepper, *Capsicum frutescens* L.; beans, *Phaseolus vulgaris* L.; and passion fruit, *Passiflora edulis* Sims (Back and Pemberton 1917). In addition, *D. cucurbitae* attacks bell peppers, as well as cultivated and feral bittermelon, *Momordica charantia* L., which grows as a weed in pineapple and sugarcane fields in Hawaii. Although much is known about its ecological habitats and effective control measures have been developed (Nishida and Bess 1950, Nishida 1954a, 1954b, Nishida and Bess 1957, Ebeling et al 1953, Steiner 1954, Steiner 1955), *D. cucurbitae* is still an important pest in Hawaii, and effectively deters the cultivation of cucurbit crops.

Biological control has not been overlooked. The larval/pupal parasitoid, *Opius fletcheri* Fullaway (Hymenoptera:Braconidae), was introduced into Hawaii in 1916 (Fullaway 1919), but its primary effectiveness has been in reducing the larval melon fly population in fruits of *M. charantia* (Newell et al 1952). Parasitization of melon fly larvae in cultivated fruits by *O. fletcheri* has been very limited (Nishida 1955).

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The principal methods developed for melon fly control are (1) mechanically covering susceptible fruits, (2) field sanitation, (3) use of trap crops and (4) use of resistant varieties (Nishida and Bess 1957). The most effective control has been obtained with insecticide cover sprays and poison baits. Malathion bait sprays applied to trap crops, such as corn and sudex grass (Johnson et al 1988), are currently used for melon fly control on the island of Molokai. Many effective insecticides formerly used for melon fly control (Gupta and Verma 1982) have been banned by the Environmental Protection Agency.

Because of the constant threat of introduction of *D. cucurbitae* into the U.S. mainland from Hawaii, there is a continuing need to update ecological information and to validate existing technology for melon fly eradication. Therefore, in 1975, the island of Molokai was chosen as a potential test site because of the presence of large fallow pineapple fields, where *M. charantia* grew as a weed. This provided an opportunity to study the population ecology of the melon fly in pineapple fields infested with bittermelon, in comparison with fields of cultivated hosts. We were concerned about the role of bittermelon as a bridge host for the melon fly between crops of cultivated hosts. The objective of this study was to determine the influence of *M. charantia* abundance on melon fly distribution on west Molokai. Also, we wanted to determine if the windy conditions which prevail on much of Molokai were detrimental to the melon fly.

METHODS AND MATERIALS

Study Area. Experimental sites (Fig. 1) were located in west Molokai in Maunaloa, Kaluakoi, Hoolehua homestead, Molokai airport, Kualapuu,

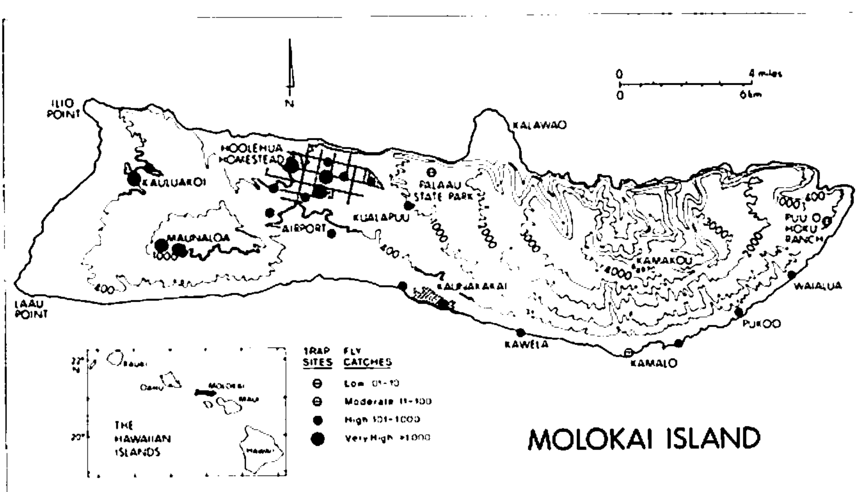

FIGURE 1. Distribution of traps, elevation contours, level of melon fly trap catches, and fruit sampling areas around trap sites on Molokai, Hawaii.

Palaau State Park, and the coastal area of east Molokai. Elevation ranged from 122 to 305 m in west Molokai and from < 15.2 to > 213.3 m in east Molokai. Sixty-three percent of the rainfall occurs in the winter; the wettest month is January and the driest month is June (Baker 1960). In Hoolehua the mean annual rainfall was 57 cm. Molokai has a mild, tropical climate due to the prevailing northeast trade winds. Optimum crop growth can only be achieved when adequate moisture is supplied by irrigation during periods of low rainfall, and when the effects of the strong winds are reduced by properly installed windbreaks, especially in areas where most cultivated cucurbits are grown.

Trapping. Population distribution and abundance were obtained by trapping. Steiner (1957) traps baited with cue-lure male attractant with 5% naled were installed and serviced monthly at sites in west, central, and east Molokai (Fig. 1). Trapping operations were divided into 2 parts to separate data collected from trapping before abandonment of Molokai Ranch pineapple fields and trapping after abandonment of the fields. A total of 9 traps were used from 1974 to 1975, before abandonment of the fields. These were increased to 24 traps which were used from 1978 to 1979, after abandonment of the fields.

Host Fruit Collecting. When fruits were available in 1978 and 1979 they were collected at weekly or monthly intervals. Where possible, randomized plots were set up and numbers of ripe *Momordica* sp fruits were counted. From 10 to 20% of the ripe fruits counted were collected and held in fruit holding buckets or boxes over sand until all the flies and parasitoids within the fruit completed development and emerged for pupation. The sand was sifted weekly, and collected pupae were held until emergence was completed, and the data recorded.

Data Analysis. Trap data were normalized by use of $(x + 0.5)^{1/2}$ transformation. Trap data means were calculated and analyzed using the Statistical Analysis System (SAS Institute 1979) with Duncan's multiple range test. Monthly rainfall totals were obtained from weather stations on Molokai from the U.S. Department of Commerce, National Oceanic and Atmosphere Administration.

RESULTS AND DISCUSSION

Trap Data. Seasonal changes in population indices of the melon fly on Molokai are shown in Fig. 2. The highest population occurred in summer of 1974. There were 2 population peaks, one early and one late in 1975 and 1976. Molokai Ranch discontinued pineapple production in late 1975. The abandoned fallow pineapple fields were soon invaded by *M. charantia*. The influence of *M. charantia* on island-wide population trends of the melon fly in 1976 was no different than in 1975. However, comparison of east-west Molokai trap catches of 1974 and 1975 with those of 1978 and 1979 showed the strong influence of *M. charantia* on the melon fly population (Fig. 3) in Maunaloa. The melon fly population increased to a significantly higher

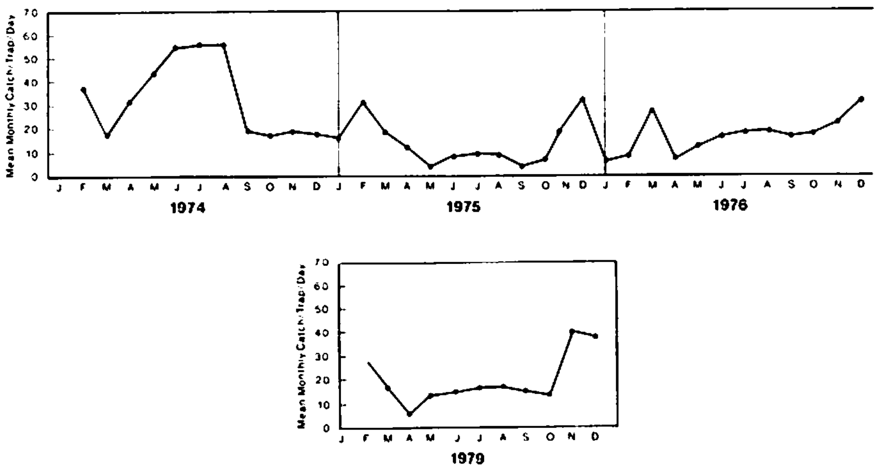

FIGURE 2. Mean monthly trends of the melon fly population on Molokai, Hawaii.

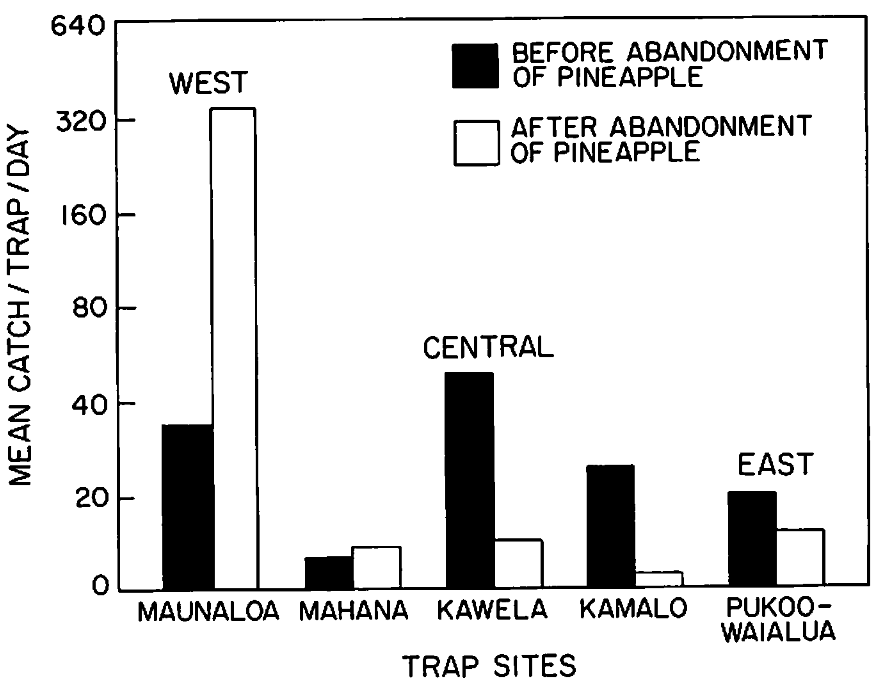

FIGURE 3. Mean melon fly trap catches, 1974-1975 (shaded columns) before abandonment of pineapple fields, and mean melon fly trap catches, 1978-1979 (unshaded columns) after abandonment of the pineapple fields; comparisons at Maunaloa, Mahana (West Molokai), Kawela, Kamalo, and Pukoo-Waialua (East Molokai).

level (P = <0.05) in Maunaloa than in any other location. There was a decrease in melon fly catches in the 4 other locations except in Mahana (west Molokai). The levels of melon fly trap catches were high in Maunaloa, Kaluakoi, and the Hoolehua homestead farming area where *M. charantia* was abundant in abandoned fallow pineapple fields. High numbers of *D. cucurbitae* were also trapped near the airport, in Kualapuu, and in some coastal locations in east Molokai. The lowest catches were obtained in Palaau State Park and Haku Ranch in high rainfall areas where bittermelon and other hosts were scarce.

Del Monte Pineapple fields in Kualapuu were not abandoned. Normal cultivation practices included control of *M. charantia* patches in these fields with herbicides.

High trap catches in west Molokai were related to the occurrence of bittermelon and cultivated hosts adjacent to each other in backyard gardens and small truck crops. Trap catches in east Molokai were related to the presence of hosts around home sites, and to migratory flies.

Host Fruit Collected. Areas from which host fruits were collected are shown in Fig. 1. Fruit production generally was patchy and widely scattered in fallow fields. Availability of vegetables and fruits in backyard gardens and truck crops depended upon the cultural practices of growers. The fruit collection data are summarized (Table 1). *M. charantia*, was the most plentiful fruit in time and space, producing a mean of 21.8 melon flies per kg of fruit. The cultivated hosts (pumpkin, and watermelon) produced a mean of 22.1 melon flies per kg of fruit.

Maunaloa village area produced significantly more (P<0.05) bittermelon and melon flies (81 per kg of fruit) than any other location. The airport and Kaluakoi open areas were second and third in the production of bittermelon and melon flies. In Hoolehua, bittermelon infestation by the melon fly was very low in comparison with infestation in pumpkin and watermelon. Surprisingly, no larval parasitoids were recovered from the 8523 fruits collected.

Melon flies were consistently produced from bittermelon in Maunaloa village when rainfall was sufficient to maintain production of fruits throughout the year in 1979 (Table 2). Fruit production by feral *Momordica* in the Kaluakoi, airport, and Hoolehua areas occurred only during the winter months when rainfall was adequate.

Our study showed that following the abandonment of pineapple production in late 1975 on the island by Molokai Ranch, there was a lag time of about 2-3 years before the fallow pineapple fields became fully invaded by bittermelon. High populations of melon flies were produced in windswept open areas due to the widespread distribution of bittermelon. Production of melon flies was highest in Maunaloa village and nearby fallow pineapple fields where bittermelon and backyard melon fly hosts were close together and rainfall was favorable. In open areas around the airport, Kaluakoi, and Hoolehua, where strong winds were prevalent, sometimes attaining speeds of 80 KPH, melon flies survived and successfully infested fruit. However, *M. charantia* fruited only when rainfall was adequate.

TABLE 1. Summary of melon fly infestation of cucurbitaceous fruits collected on Molokai, August 1978 to January 1980.

Location	Host[1]	Total fruits counted or estimated	No. of Samples	No. of Fruits	Total[2] Pupae	No. of *D. cucurbitae* emerged	Percent Eclosion	No. of *D. cucurbitae* /kg fruit
Maunaloa Village	B	63,159	385	7,045	2,042	1,637	80	81.0
Airport Area	B	6,099	60	839	78	73	93	4.0
Kaluakoi	B	3,497	39	471	151	123	81	2.6
Hoolehua	B	1,363	16	90	161	91	56	.8
	P	15	3	15	736	647	88	37.0
	W	890	1	2	149	132	88	7.5
Kaunakakai	S	21	1	21	0	0	0	0.0

[1]B = Bittermelon; P = Pumpkin; W = Watermelon; S = Sweet pepper.
[2]No larval parasitoids recovered.

TABLE 2. Summary of monthly melon fly trap catch per trap per day, and bittermelon infestation rates, at 4 locations on Molokai in 1979.

Location	Rates	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Maunaloa Village	CPTD*	50	22	38	32	6	59	73	119	0	161	241	347	1148_a
	/kg fruit	160	38	0	.2	4	35	15	26	0	16	16	80	465.2_a
Airport Area	CPTD	39	44	23	2	3	5	25	.8	0	.6	2	2	146.4_b
	/kg fruit	180	0	0	0	0	0	0	0	0	0	0	0	180_b
Kaluakoi	CPTD	19	14	13	1	2	5	.8	.3	0	.4	.9	.1	56.5_b
	/kg fruit	0	0	0	0	0	0	0	0	0	0	0	0	0
Hoolehua Area	CPTD	39	61	35	4	9	3	13	9	0	5	52	64	294_b
	/kg fruit	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	CPTD	147^{a}**	141^{a}	109^{ab}	39^{ab}	20^{ab}	72^{ab}	111.8^{ab}	129.1^{ab}	0	167^{ab}	295.9^{a}	413.1^{a}	1544.9

*Total flies captured per trap day.
**Monthly and site values followed by different letters are statistically different at the 0.05 level. (ANOVA).

The association of high trap catches with *M. charantia* host abundance agrees with the work of Harris et al 1986, which showed that high trap catches on the island of Kauai were associated with host plant abundance in commercial and residential plantings. The difference on Kauai was that *M. charantia* was found in sugarcane fields instead of pineapple.

We speculate that *Opius fletcheri*, which attacks melon flies on the other Hawaiian islands, was not recovered on Molokai because of the high winds which probably are unfavorable for its survival.

At the present time, abandoned pineapple fields at Molokai Ranch have been planted to pasture grasses for cattle grazing. *M. charantia* is under control as a result of habitat modification, except in a few small isolated places. Commercial cultivation of cucurbits on Molokai has increased, but melon fly is under control by means of an IPM program. Our results show that the magnitude of the melon fly problem is strongly dependent upon bridge hosts which may maintain the melon fly at high levels between cultivated crops. The results also indicate the potential importance of environmental factors such as wind on suppression by parasitoids.

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